ALTERNATIVE TO THE IMPORT SUBSTITUTION POLICY IN RUSSIAN RADIO-ELECTRONIC COMPLEX

Nikolay A. Ganichev

Institute of Economic Forecasting of the Russian Academy of Sciences

117418 Moscow, Nakhimov avenue, 47, Russia

Abstract
One of the main problems of the Russian science-intensive and high technology complex is a huge dependence on imported component base. Meanwhile approaches for its solution used by the Russian Government seems to be insufficient and inefficient especially in the long run. The author discusses an alternative way of development for radio-electronic industry in Russia that is to fund several long-term promising chip production technology of new generation. The results of comparative prognostic calculations for two development scenarios using an intersectoral balance model for science-intensive and high technology complex is provided.

Key words: *innovation, high-technology, economic modernization, Russian economy, electronic complex, radio industry, forecast, import substitution program*

1. INTRODUCTION

Today one of the most widely discussed problems of Russian science intensive high-technology complex (SHTC) is its high dependence on imported electronic component base (ECB). Civil and defense enterprises in all SHTC sectors are forced to buy foreign-made chips in order to keep civilian products competitive in domestic and foreign markets. Particularly acute problem of dependence on imported component base is appreciated after sharp aggravation of political situation at the beginning of 2014 and when the USA and EU introduced sanctions against Russia. The sanctions can threaten cooperation in several areas and supply of imported parts and equipment vital for production of several defense products. Dependence of Russian producers on imported ECB is particularly acute in guided missile and space industry (GM&SI), aircraft industry (AI) and directly in electronic complex (EC). Latest ECB designs protected by specific standards are not available to Russian companies due to the restrictions set by U.S. and European manufacturers. Use of lower-quality component base results in lower reliability of entire range of Russian high-tech products.

As a result, Russian companies are slowly beginning to abandon purchases of domestic satellites and start purchasing ready-made satellites of foreign manufacturers. For example, the tender conducted by Kosmicheskaya Svyaz (Satellite Communications or GPKS) state company for delivery of Express AMU2 heavy communication satellite in late 2013 was won by Astrium SAS European corporation that have beaten Russian producer Reshetnev ISS. On this background the Russian leadership sets the task to organize production of all products required for the military industrial complex in Russia "to provide our independence in all branches of army and navy re-equipment by new weapons systems" (Meeting on defence procurement 2014).

In this paper we consider one of the options to solve this problem, but in the long term rather than short term. The article analyzes the statistics of foreign trade activity of the Russian Federation; it identifies the volume of shipments on microelectronics imported in Russia, as well as parts and components used for microelectronics production in Russia. The strategy implemented by the Russian government to reduce EC dependence on imported components is considered, and its shortcomings are identified. An alternative approach to solving the problem of reducing dependence on foreign ECB in the long term, as well as a forecast of EC production for two alternative industry development options (including implementation of the currently approved set of measures and the alternative approach) is given in the conclusion.

2. ANALYSIS OF IMPORT OF ELECTRONIC PRODUCTS AND THEIR COMPONENTS TO THE RUSSIAN FEDERATION

According to OECD classification, Russian SHTC includes the following (Report to the OECD 2009):

- Aerospace industry (ASI) including aircraft industry (AI) and guided missile and space industry (GM&SI);
- Nuclear industry (NI);
- Production of complex (sophisticated) machines and equipment (complex equipment or CE) including arms industry (AI), weapons and special chemistry industry (WI) and shipbuilding industry (SI);
- Electronic complex (EC) including electronic industry (EI), radio industry (RI) and communications industry (CI).

In this paper we consider EC with production formed by the following items according to All-Russian Classifier of Types of Economic Activity (OKVED):

- 30 Manufacture of office equipment and computers;
- 32 Manufacture of radio, television and communication devices, production of electrical and radio elements and electrical vacuum devices;
- 33.2 and 33.3 Manufacture of instrumentation.

It should be noted that most of EC products are currently classified as defense products (mostly various anti-aircraft missile systems and special purpose electronic equipment), thus the corresponding statistics is not published in the public domain. The data on the supply of imported component base and other equipment under contracts concluded within military and technical cooperation (MTC) are also unavailable, so in this paper we consider only public data provided by the State Statistics Service and the Federal Customs Service of Russia.

The statements of official Russian authorities often contain disturbing information on almost complete dependence of Russian EC on imported components and foreign supplies. However, if we consider specific statistics of foreign trade activities then the picture is less dramatic. For data analysis we used statistics on foreign trade activities of the Russian Federation and considered the following product types from Uniform Commodity Description and Coding System (UCDCS) supplied to the Russian Federation from abroad:

Finished EC products:

- 8470 - Calculating & account machines, cash registers etc.;
- 8471 - Automatic data process machines, magnetic reader, etc. computer hardware;
- 8517 - Elec. apparatus for line telephony, telephone sets, pts;
- 8518 - Microphones, loudspeakers, sound amplifier etc, pt;
- 8519 - Turntables, record & cassette players etc.;
- 8521 - Video recording or reproducing apparatus;
- 8523 - Prepared unrecorded media (no film) for sound etc.;
- 8525 - Trans apparatus for radiotelephony etc, TV cameras cordless telephones;
- 8526 - Radar apparatus, radio navigation aid & remote cont app;
- 8527 - Reception apparatus for radiotelephony etc.;
- 8528 - Television receivers (incl. monitors & projector receivers);

Components for EC production:

- 8522 - Parts & access of record play, mag tape record etc.;
- 8529 - Parts for television, radio and radar apparatus;
- 8532 - Electric capacitors, fixed, variable or adjustable (preset);
- 8533 - Electrical resistors except heating resistors, pts;
- 853400 - Printed circuits;
- 8541 - Semiconductor devices, light-emit diodes etc., pts.;
- 8542 - Electronic integrated circuits & microassemblers, pts.;
- 8473 - Parts etc for typewriters & other office machines computer accessories.

Analysis of statistics on these commodity groups showed that EC finished products in the amount of $127.9 billion and spare parts and components for them in the amount of $21.2 billion were imported to Russia in the period from 2005 to 2013. The total volume of EC gross production in Russia during the same period amounted to 1664.83 billion rubles or $151.3 billion. At the same time the share of imported parts and components in the total output of Russian EC products during the analyzed period was about 14%. That is substantially less than the data declared by the leadership of the Russian Federation. However, statistics for only very large OKVED commodity groups is available publicly. Thereby the volume of Russian EC products may consider equipment and products not related to electronics. Furthermore, according to UCDCS the products with commodity code 8471 accounted for as finished EC products, include not only assembled computers, but also their individual components that can be used for knock down assembly of finished products in the territory of the Russian Federation. Thus, the actual share of imported components in the cost of EC products manufactured in the Russian Federation may be substantially higher. If we consider the total volume of imported electronic products then it is roughly equal to similar products produced domestically.

Moreover, the volume of imported electronic products exceeded the volume of its production in the Russian Federation in 2006, 2007, 2008 and 2011. At the same time, import of EC components and finished products was growing faster than electronics production inside the Russian Federation. Import of spare parts grew at the average rate 23% per year, import of finished products grew by 20% and EC production of Russian enterprises grew only 17% annually. The dynamics of all three indices is shown in Fig. 1.

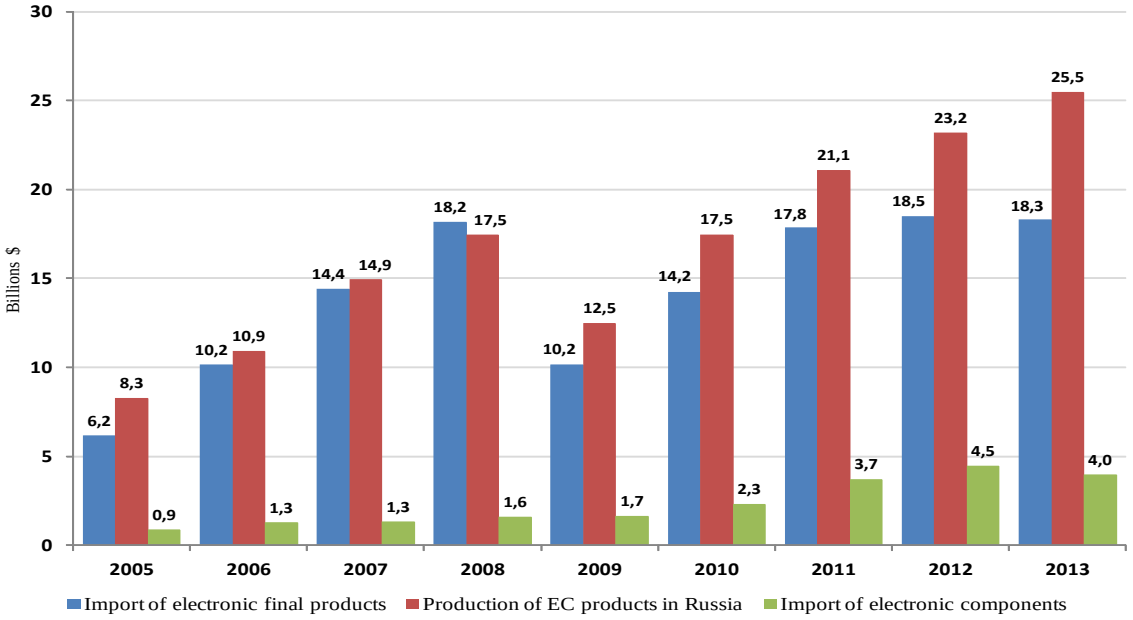

Fig. 1. EC production dynamics in Russia and dynamics of import of similar products and parts for their production (Source: Federal customs service of Russia and Federal state statistics service of Russia)

The largest shares of EC products imported to Russia in the analyzed period were telecommunications equipment amounting to $49 billion (38.8% of total EC import), computers and computer units amounting to $32.8 billion (25.6%), transmitting equipment for radio broadcasting and cellular communications amounting to $16.4 billion (12.7%) and television equipment amounting to 13.2 billion dollars (10.4%). More detailed structure of EC products import to Russia is shown in Fig. 2.

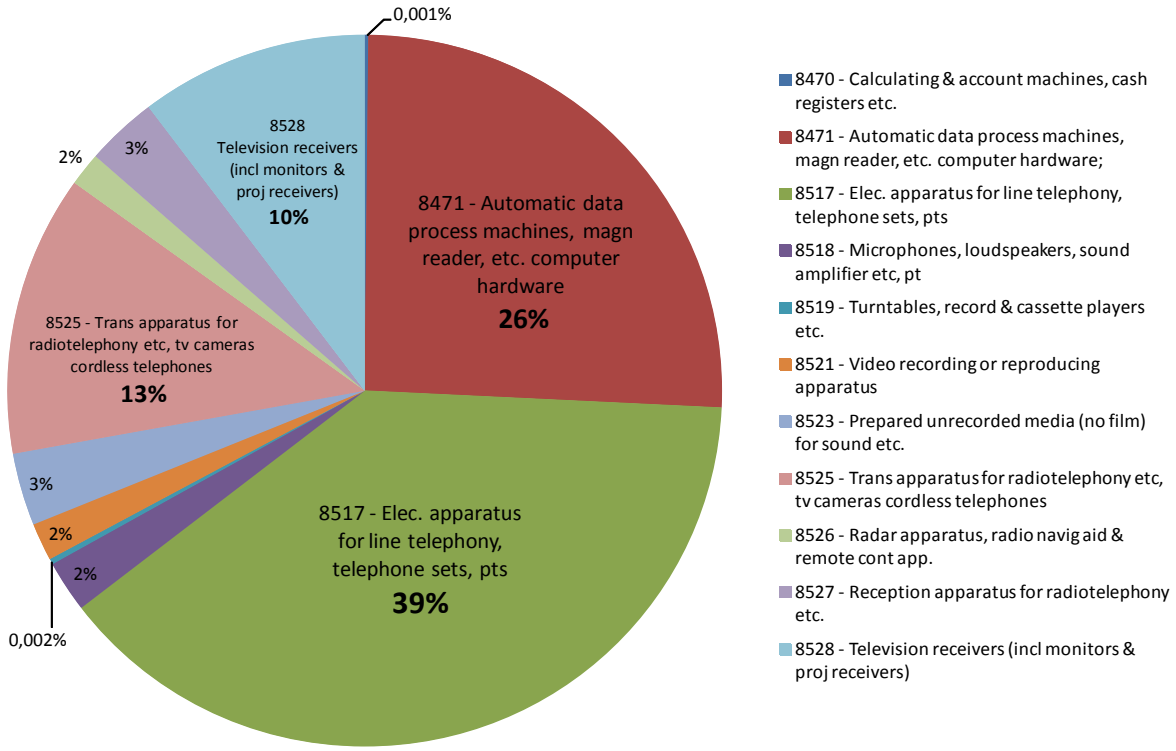

Fig. 2. Structure of import electronic final products to the Russian Federation for the period from 2005 to 2013 (Source: Federal customs service of Russia)

We should also note that the customs statistics does not account for a significant amount of imported components supplied by classified defense contracts under various military-technical cooperation programs. At the same time, according to some sources the share of imported electronic components in the production of military products is also very high and it reaches 80%. Noteworthy is the fact that the greatest demand of imported parts and components for electronics in Russia in 2005–2013 was due to the elements for television, radio, as well as radar stations. They can also be used for production of anti-aircraft facilities and aviation equipment. The total volume of goods delivery for the period amounted to $12.9 billion and it was over 60% of all deliveries of imported component base. A significant share in imports of components is also formed by office equipment components and electronic integrated circuits. See Fig. 3.

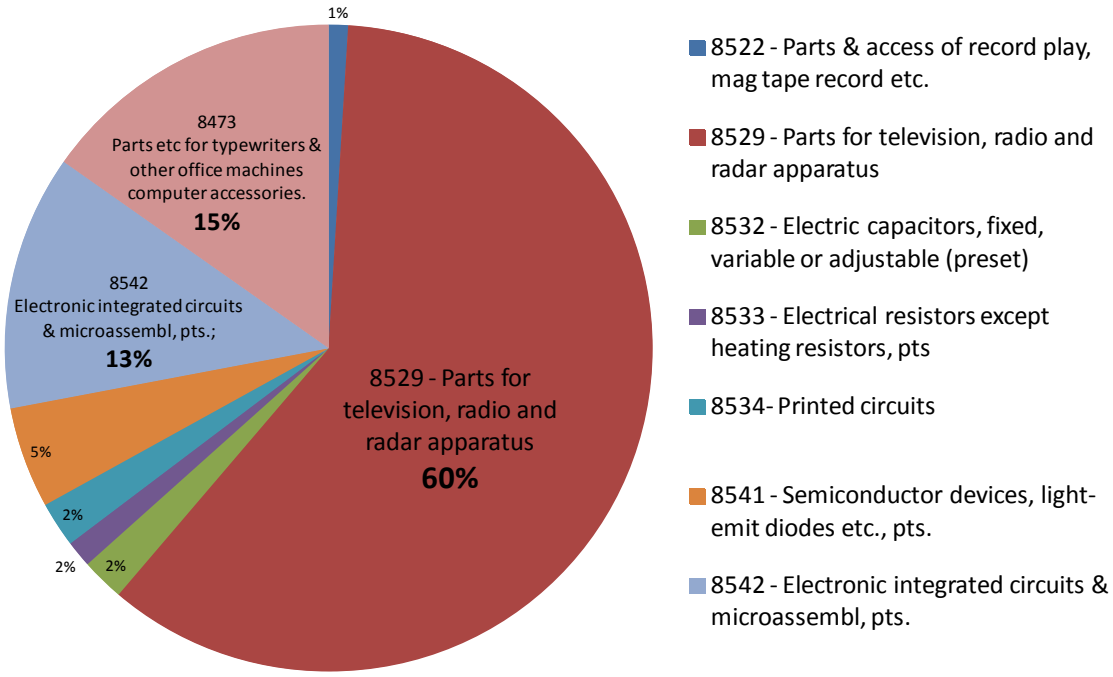

Fig. 3. Structure of imports of electronic parts and components to Russia for the period from 2005 to 2013 (Source: see ibid.)

Given the large volume of imports of ready-made telecommunications products, including transmission equipment, we can state that the Russian market of information and communications technologies (ICT) is very heavy dependable on import. At the same time, import substitution in the segment of equipment for building fourth generation mobile networks that rapidly develops in Russia could give a powerful impact to production of Russian electronic equipment (Ganichev 2013).

However, the most important task in the field of electronics import substitution is not so much to promote economic development of high-tech industries as to ensure the independence in the supply of the most important components for the defense industry. Most of electronic components are imported to the Russian market by authorized distributors. Such companies value their reputation, they strictly comply with all export rules and commit themselves to supply only if they have all required authorizations. A considerable part of electronic components required by Russian defense industry can be supplied by American production in Russia only by a special permission. The terms of exporting such components is regulated by ITAR (International Traffic in Arms Regulations) special rules set, according to which the export of military category (for use in military systems) and space category (radiation-hardened components) ECB to Russia is possible with a permission of the U.S. State Department. The U.S. government very tightly controls the transfer of advanced technologies to third countries. To order any electronic equipment in the U.S., it is required to inform regulatory authorities

exactly for which purpose it is intended and how it will be used. In addition, the entire range of imported chips is permanently revised and outdated samples are removed from production. This poses a particular danger for the design of new equipment. At any time you may find that a significant share of the element base that should be in the project was just taken out of production, or that it is impossible to buy it due to the constraints.

3. ALTERNATIVE TO THE IMPORT SUBSTITUTION POLICY IN RUSSIAN ELECTRONIC COMPLEX

In order to stimulate import substitution of electronic appliances, the Russian Government is taking a number of administrative measures and allocates a huge budget. For example, from 2005 to 2013 only within Federal Target Programs (FTPs) for stimulating EC production 416.4 billion rubles were assigned, including 190.6 billion rubles of capital investment into infrastructure and modernization of the enterprises and 112.7 billion rubles more for R&D.

The annual volume of state investment in development of EC production is comparable with the annual investments in R&D and production facilities made by major companies producing radio-electronic components such as Xilinx, Intersil and International Rectifier combined. Meanwhile, just one fifth of the nomenclature produced by these companies covers the majority of needs of the Russian producers in imported components (Pokrovsky I. 2012).

However, the problem is not only in the low efficiency of budget spending. The strategic goals used in the state program to encourage EC production look ineffective. If one analyzes 'Development of Electronic and Radio Industry in 2013–2025' state program, then it is easy to see that it was initially based on the principle of EC 'catch-up' development. The program mainly includes target indicators characterizing either the share of domestic products in domestic and foreign markets, or achieving a certain technological level of chip production to a certain date. In our opinion, these indicators do not reflect correctly the most urgent Russian EC modernization goals.

The first group of indicators is not quite correct, as the concept of 'domestic products' is now very blurry. The procedure used to determine 'domestic' equipment was approved by a joint order of the Ministry of Industry and Ministry of Economic Development of the Russian Federation in 2011, and it implies that the equipment will be considered 'Russian' if the level of localization of production in the Russian Federation amounts 60–70%. According to the adopted procedure for calculating the share of imported components not all imported parts and materials will be considered, but rather only those for which analogues are produced in Russia. As a result, based on the approved criteria of Russian equipment, the equipment just assembled from imported parts that are not manufactured in Russia may be recognized as 'Russian', provided that production costs in the form of electric energy consumption and wages will form at least 60% of the production cost.

Target indicators of the second group should be achieved at the expense of purchasing completely finished imported technological equipment. In fact, all huge investments that are sent to technical re-equipment under Russian state programs are nothing but a support of the largest foreign manufacturers of microprocessors. For example, the main target indicators of EC development state program provide to introduce chip production technology with topological size 0.010 microns by 2025. At the same time, Intel plans to reach this technological level already in 2017–2018. So it is quite likely that in 2025 Russian companies would just buy ready-made already obsolete by the time equipment from American manufacturers (if the latter would agree to sell it). Considering that Russia creates a system of design centers, starts commercial production of modern microprocessor chips at imported equipment, and wins certain market niches in microelectronics, and even then the country would not be able to get rid of technological dependence in the long term.

In the context of the above problems it seems highly appropriate to develop fundamentally different approach to modernization of Russian EC that would leave 'catch-up' development strategy for this sector. In our opinion, such alternative approach may be a rejection of EC technological modernization program based on purchasing imported aging process equipment, and redirection of the released

budget to funding the most promising research areas in the field of microelectronics and photolithography that will be required in the medium term, from 2020 to 2025 and later. It is advisable to make the main emphasis on development of photolithographic equipment for production of chips with topological size of 6 nanometers and less based on sources of soft X-ray or extreme ultraviolet (EUV) radiation.

Currently, only two companies in the world are developing photolithography machines based on design rule less than 20 nm; they are Dutch ASM Lithography and Japanese Nikon. However, Russian scientists have unique experience in certain areas required to create such equipment technologies. Works in the field of X-ray optics in the wavelength range from one-tenths fraction of angstrom are conducted in the Institute of Microstructure Physics (IMP) of the Russian Academy of Sciences (RAS). Dutch company ASM Lithography uses the developments of IMP. Moreover, IMP holds a global monopoly on production of special 20 nm thick filters that are used in all lithographic machines in the world that protect the 'mask' of the chip against penetration of foreign particles resulting from friction of moving parts inside the plant.

The Institute of Spectroscopy (ISAN) of the Russian Academy of Sciences works in Russia on creation of radiation sources with the desired wavelength. Two alternative types of EUV emitters and unique designs of radiation sources with wavelength 6.5 to 6.7 nm are developed there; they permit to reach theoretical resolution 3 nm and therefore proceed to manufacturing of quantum computer elements. Planar Company (Minsk, Belarus) and Amphora Laboratory (Moscow) work on ultra-precise positioning systems.

These are just several examples of successful Russian research teams involved in global cooperation on development of innovative microelectronic production technologies. Complex development of these and other areas of research can result in formation in Russia of all necessary conditions for creation in the next 10–15 years of not just the next generation of its own photolithographic equipment, but rather its fundamentally new class. Deployment of mass production of chips with topological size 6 nm with the use of domestic technology in 2020–2025 would eliminate the existing gap from the global leaders in the field of microelectronics and ensure the required level of independence of the Russian high-tech industry from imported component base.

The maximal task within the alternative approach to the strategy of EC technology development may be creation on the basis of the existing domestic base an installation with lithographic resolution less than 20 nanometers by 2020–2025. However, despite the existing capacity in relevant scientific developments solution to this problem seems unrealistic. In order to establish commercial production of all elements for production of necessary photolithographic equipment it is required to create industrial interferometers to produce ultra-precise optics, develop industrial design and manufacturing process and metrology of super-smooth surfaces, develop technology and equipment for precision shape correction of optical surfaces, etc. Russia does not have the appropriate industry and it is impossible to create it from scratch within the next 10–15 years.

The only way to ensure Russia's independence on import electronic components in the long term is to enter into an alliance with the leading lithography equipment manufacturers. Now completely independent work on the full cycle of development and production of such facilities is actually executed only in Intel research center. All other developments are executed by international alliances that unite the efforts of several companies. The system of participation is very flexible. A member company can either become a shareholder or pay for participation in the projects to particular specialists from other fields or acquire any specific technologies and experimental results, etc. If Russian companies enter into such union, then they need to find optimal conditions for cooperation which in effect would permit to fully enjoy the benefits of the alliance. Currently all developments of domestic scientists in these areas are actually financed by foreign customers who buy all patents on Russian inventions. The key point in building EC development strategy should be the reservation of these patents for Russian producers and creation of the conditions on which foreign companies would fall into dependence on the Russian scientific developments by 2025–2030.

4. FORECAST AND CONCLUSION

In order to study the potential economic impact of implementation of the proposed approach to EC modernization we used a predictive model developed in the Laboratory of Analysis and Forecasting of High-Tech Industries and Markets of the Institute of National Economical Forecasts (INP) of the Russian Academy of Sciences that takes into account cooperative links between individual SHTC units. The method is based on construction of simplified tables of inter-industry balance that includes four SHTC units, Science and Scientific Services branch, as well as the rest of the economy aggregate that combines the indices for other economic activities. Technological factors of inter-unit links were calculated based on combination of statistical indicators for certain types of economic activities by OKVED with structural performance of individual SHTC sectors and subsectors received in the result of joint research of the Institute of Economic Forecasting of Russian Academy of Sciences and TS-VPK agency. Initially we estimated the amount of demand for SHTC products from the side of the state for the entire forecast period based on the analysis of state policy documents determining development priorities for individual sectors of the complex for the long term and the methods used to estimate budget expenditures for military products. In order to assess the dynamics of technological coefficients we also evaluated target indicators of long-term development programs that permitted to consider additional restrictions related to the structure of cooperative links within the complex for SHTC long-term forecasting and increase forecast reliability (Frolov, Ganichev 2010).

In order to evaluate the effectiveness of the alternative scenario of EC state incentives, we changed the initial parameters of the model. The financial assets that had been used as EC funding parameter, within the accepted hypothesis were used to finance Science and Research branch; we also made a number of other adjustments in the basic parameters of the model. Application of the model based on inter-industry balance methods permitted to consider the impact of cooperative links and show stimulating effect that the alternative scenario might have to support both EC and other high-tech industries.

The results of predictive model calculations for EC production under the base and alternative scenarios until 2030 are given in Fig. 4.

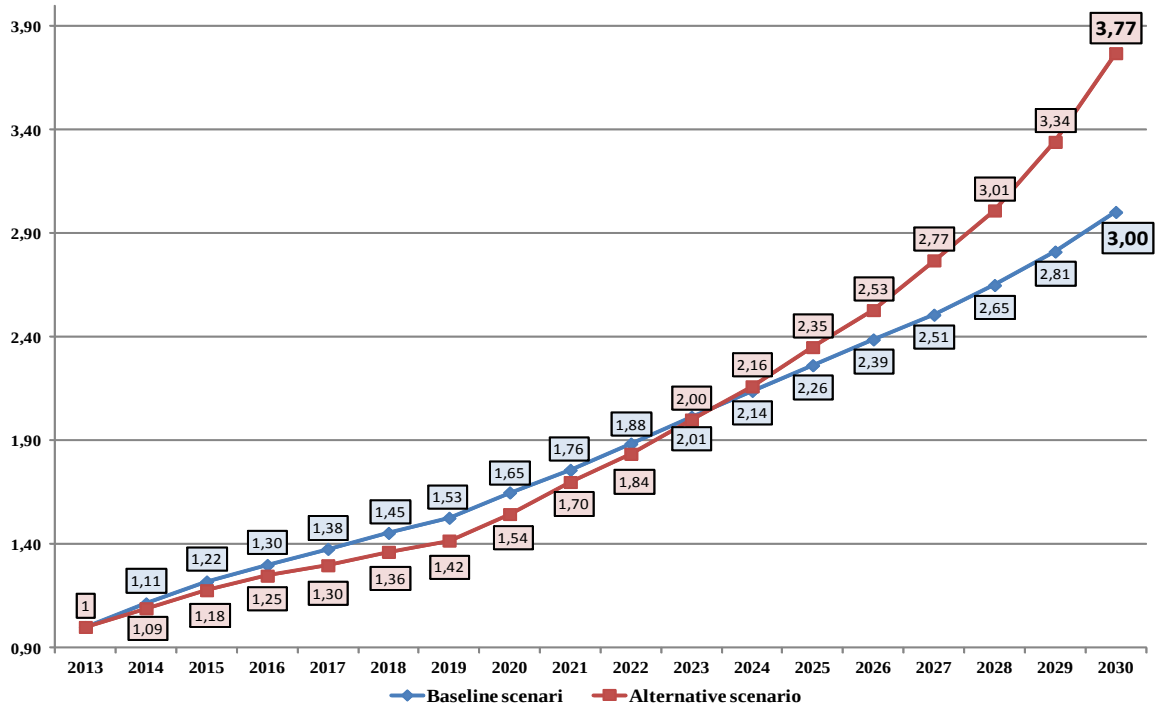

Fig. 4. Russian EC production forecast for base and alternative scenarios

One can see that the alternative scenario of EC simulation would result in some decrease in EC production in the short term, but it would provide a sharp increase in output by the end of the forecast period. Furthermore, the main economic impact of the development of new methods for microprocessor production is expected after forecast model horizon, i.e. after 2030.

Comprehensive support for system development in advanced photolithography in Russia should become the basis for fundamental research in other areas of microelectronics that would have to be decisive in the long term (after 2030). These are bioprocessors, organic, quantum and optical devices, which are expected to emerge between 2030 and 2040. Currently the global works in these areas are conducted at a fairly broad front, but the developments suitable for commercialization are expected after 2020. Developments based on spin electronics may become promising for Russia in this respect. Furthermore, it is required to conduct studies in the field of combining different processor types, such as mechanical and electronic nanocomputers, biochemical, optical, quantum computers, etc.

In conclusion we note that the main effect from implementation of the proposed measures to stimulate the EC should not be so much the rapid growth of EC production in terms of money, but rather a qualitative change in the system of Russian microelectronics production and reduction of the dependence on imported technology for the defense industry of the Russian Federation. Furthermore, we should emphasize once more that the proposed approach is designed to produce the effect in the long term while keeping a high dependence on imports of foreign ECB in the coming years.

Therefore, solution of more local problems should be the task for the near future. It is required to determine the full range of components used to manufacture military and aerospace equipment. One should determine which part of this nomenclature can be produced in Russia (probably using the imported equipment) and which part can be purchased abroad using reliable supply chains independent of political considerations.

For the remaining part of the nomenclature, the use of which will bear the maximum risks for the Russian defense industry, it is required to determine the possibility of replacing it by analogues produced in Russia. If such replacement is impossible then it is necessary to evaluate the terms required to redesign the electronic module in order to eliminate the use of the component in the circuit. It is required to make a program to rework all the modules where the components of the maximal risk group are used. Private sector companies should be engaged to develop new modules using Russian and foreign available components. The result of this work should not be only a fundamental reduction of dependence on export control of the components to Russia, but also a significant restructuring of the industry, such as involvement of private Russian companies in the military-industrial complex and faster rotation of qualified personnel in the direction to more efficient companies. Furthermore, it would lead to the emergence of many innovations that with participation of private companies would be used in the development and production of commercial products.

In the civil industry the main task in short and medium term should be to search and fill in the new system niche emerging at information and communication technology markets. The main priorities of the electronic industry development should be various special microelectronics branches that do not require mass production: microwave electronics, radiation-hardened electronic component base and microsystem technology.

It is expected that before the industrial production of a new generation microchips (less than 10 nm) performance of computers and different subscriber communication devices will be increased primarily due to extensive factors, such as increasing the number of processors in a single device and use of GRID technologies. The most demanded technologies in the field of increasing computational power of computers and mobile subscriber units should become cloud and GRID computing. Virtual computers based on multi-core processors, as well as cluster structures formed using broadband or backbone networks will be created. Research in these areas require, above all, development of new software types, and Russian programming school still keeps competitive position in the global market.

REFERENCES

Federal Customs Service of Russia 2014, *Database of customs statistics*, <http://stat.customs.ru/apex/f?p=201:1:3369383328097346>.

Federal State Statistics Service of Russia 2014, <http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/main/>.

Frolov I.E., Ganichev N.A. 2010, 'Long-term development of the Russian high technology complex under unstable growth of the world economy (model and forecast)', *Studies on Russian Economic Development*, Vol. 21, no. 6, pp 573-588.

Ganichev N. A. 2013, 'Scenarios of the joint innovative development of the radio electronic industry and services sector, Studies on Russian Economic Development, vol. 24, no. 4, pp 344-352.

Ministry of Education and Science of the Russian Federation 2009, *National innovation system and state innovation policy of the Russian Federation - Background Report to the OECD Country Review of the Russian Innovation Policy*, Moscow, .p. 89-93.

Order of the Ministry of Industry and Ministry of Economic Development of the Russian Federation No. 1032/397, dated August 17, 2011, <http://www.minpromtorg.gov.ru/docs/interagency/2>.

Pokrovsky I., 2012, 'How to jump off the electronic needle', Expert, no.41 (823).

Transcript of the meeting of the President of the Russian Federation with members of the Russian Government on implementation of the state defense order, May 14, 2014 <http://www.kremlin.ru/news/21021>.